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ALIGNMENT OF AN OPTIC OR ELECTRONIC COMPONENT

The present invention relates to a method for aligning an optic or electronic component, and especially for aligning an optic fibre and an optoelectronic component mounted on a substrate. The present invention relates also to an arrangement for aligning an optic or electronic component, and especially for aligning an optic fibre and an optoelectronic device mounted on a substrate.

In optoelectronic applications transceivers mounted on a substrate, such as a low or high temperature cofired ceramic (LTCC, HTCC) substrate, are used to convert electrical signals to optical signals and vice versa. Optic fibres transmit the optic signals. The fibres have to be aligned precisely with the transceivers in order to make a proper connection between the optic fibre and the transceiver.

US-B1-6,217,232 discloses a method and apparatus for coupling an optic fibre to the output of an side emitting optoelectronic device. The optoelectronic device is mounted on a substrate and aligned with the optical axis of the optic fibre by using posts formed on either the substrate or the optoelectronic device and matching resesses formed on the other. Three or more posts and recesses will be formed on the mounting surfaces so as to provide only one possible alignment. The optic fibre is arranged parallel with the substrate plane in a V-shaped channel formed on the substrate and being capable of retaining the optic fibre in a predetermined alignment relative to the optoelectronic device aligned by posts and recesses.

Forming the V-shape groove and the posts and recesses are generally performed by different processes which may cause alignment errors between the V-shape groove and the posts and recesses. Especially when the V-shape groove has a relatively large width and a depth the alignment error increases and the coupling between the optoelectronic device and the optic fiber is poor. Further, prior art alignment methods are relatively labor intensive and costly.

The object of the present invention is to eliminate the disadvantages of the prior art and to provide a new method for mounting an optic or electronic component on a substrate and especially aligning an optic fibre with the component with improved aligning accuracy. The object of the present invention is also to provide a new arrangement for mounting an optic or electronic component on a substrate and especially aligning an optic fibre with the component with improved aligning accuracy.

In the present invention the component is aligned on a substrate and especially an optical fibre is aligned with the component, for example an optical surface emitting light source chip component, such as RCLED or VCSEL, by using stud bumps made on the chip top metallization. The stud bumps are manufactured with a wire bonding method and act as a mechanical structure, but also as an electrical contact especially to the substrate metallization. In the present invention, the outer surfaces of the stud bumps formed on the component are used to align the component with an opening in the substrate or a corresponding support structure. Additionally the inner surfaces of the stud bumps may be used to align an optic or optoelectronic element to the component. Characteristic features of the present invention are in detail presented in the enclosed claims.

In the present invention, the optic or electronic component and also the optical fibre are aligned mechanically and accurately. Further, aligning can be performed by using same stud bumps for aligning both the component on a substrate and the optical fibre with the component. This allows for low manufacturing cost. Further, the optical fibre becomes almost in contact with the light source, which improves coupling. The multilayer ceramic technology enables the manufacture of light emitter arrays and the integration of the controller electronics on the same module.

In the following, the invention will be described in more detail with reference to the enclosed drawing, in which

Fig. 1 presents passive alignment of an optic fibre with a light source of a RCLED according to the present invention,

Fig. 2 presents a RCLED bumping for passive alignment in Fig. 1,

Fig. 3a presents a stud bump made with a gold wire, and

Fig. 3b presents a top view of a stud bump of Fig. 3a.

Figure 1 presents aligning an optic fibre 1 to a resonant cavity LED chip 2 and the latter on a substrate 3. The LED 2 is mounted on a bottom side of the substrate 3

In the present invention the resonant cavity LED component 2 is aligned on the substrate and the optic fibre 1 is aligned to the LED 2 by using for example four stud bumps 5 made on the chip top metallization 22 (Fig. 2) facing the substrate by using a wire bonder and arranged symmetrically along the periphery of the bottom opening of the hole 4 to provide only one possible alignment. The stud bumps 5 act as a mechanical structure for the LED 2 and fibre 1 alignment, but also as an electrical contact to the substrate metallization.

The substrate consists of three dielectric layers, bottom layer 31, center layer 32 and top layer 33. The thickness of the layers is typically for example 200µm. The substrate 3 may be either with low temperature or high temperature cofired ceramic (LTCC, HTCC).

The optical fibre 1 is mounted perpendicular to the plane of the substrate 3 through a hole 4 in the substrate 3 and aligned to the LED 2. The hole 42 through tape layers 32 and 33 is slightly bigger in diameter than the fibre diameter. The bottom dielectric layer 31 has a bigger hole 41, and a metallization 6 on the hole walls, to center the chip component 2 using the stud bumps 5.

The stud bumps 5 are formed by using a ball bonding apparatus according to following steps: a) A small ball is formed at the end of the wire, for example Au wire, passing through a bonding tool. b) The bonding tool is caused to press the small ball against the electrode for bonding thereto and forming the stud bump. c) The bonding tool is moved vertically from the surface of the electrode so that the Au wire is cut from the stud bump.

The stud bum 5 consists for example of a broad bottom part 51 with rounded walls 52, a conical middle part 53 with downwards sloping walls 54 and an narrow upper part 55 with rounded end portion 56. There are small horizontal brims 57, 58 between the different parts (Figures 3a and 3b).

In the assembly, the light source chip 2, equipped with stud bumps 5 with bottom parts against the surface of the chip, is mounted first to the substrate 3 by using the outer parts of surfaces 52 of the bottom parts 51 of the stud bumps for mechanical centering.

The optical fibre 1 is led through the substrate 3 and aligned to the chip 2 provided with metallization 21 on the surface facing the substrate by arranging the fibre between the stud bumps and by using the conical shape of the inner surfaces of stud bumps located symmetrically on four sides of the radiating source 22, as shown in Figure 2, so that the fibre 1 end finally is supported by the brims 57. The shape of the bumps can be further developed for maximum alignment accuracy by proper bonding tool design and by the optimisation of the bonding parameters.

A conductive adhesive 7a can be used on the stud bump 5 outer surfaces to accomplish an electrical connection to the metallization 6, if necessary. A non-conductive adhesive 7b is used at the chip edges to attach it firmly to the substrate 3. Typically, the other chip electrode is wire bonded with a bond

wire 8 to the substrate. Further, the fibre 1 is tightened to the hole 4 with adhesive 9 in the upper opening of the hole 4.

The accuracy of the fibre 1 and chip 2 alignment is dependent on how accurately the bumps 5 are positioned on the chip 3. The stud bump 5 itself is repeatable within a few micrometers. It is, however, necessary to center the chip within +/- 15 µm to enable the optical fibre alignment and to avoid excessive bending of the fibre. The stud bump positioning accuracy is typically +/- 5 µm using a standard automatic wire bonder. This would mean a maximum misalignment of about 10 µm. With special bonding equipment development, the accuracy could be even better.

It is obvious to the person skilled in the art that different embodiments of the invention are not limited to the example described above, but that they may be varied within the scope of the enclosed claims. The substrate may be of another type than presented above, consisting of at least two different layers. The number of stud bumps is not limited to four. However, there have to be at least three stud bumps arranged symmetrically along the periphery of the bottom opening of the hole to provide only one possible alignment. Further, the optoelectronic component may also be of any other surface emitting component that can be applied in the optoelectronic telecommunication or other systems, but also any other passive or active electronic or optic component that have to be aligned on a substrate. And further, the sud bump may be connected to the substrate without a conductive adhesive for example by using direct bonding methods, such as ultrasonic bonding or thermocompression bonding. It is also possible to use solder stud bumps which can be connected to the substrate with a solder connection.